FINAL

Government of Nepal

Ministry of Federal Affairs and Local Development

Central Level Project Implementation Unit

Earthquake Emergency Assistance Project

Lalitpur, Nepal

Earthquake Emergency Assistance Project

(ADB Loan 3260-NEP)

Detailed Project Report

Okhaldhunga – Rumjatar Road

Rehabilitation and Reconstruction Project

Ch. 0+000 to Ch. 11+100

Okhaldhunga

Section II: Detail Engineering Survey, Design and Estimate

VOLUME 1: MAIN REPORT

November 2016

Prepared by:

Joint Venture of SILT Consultants, TSE, ECN, EC in association with Geocom International

on behalf of

AF-ITECO Ltd. Switzerland

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Joint Venture of SILT Consultants (P) Ltd, TSE, ECN, EC in association with Geocom International (P) Ltd.

November 2016

EXECUTIVE SUMMARY

The detailed engineering survey, design and cost estimate for rehabilitation and reconstruction of Okhaldhunga – Rumjatar Road has been prepared for ADB funded EEAP project following the principles of build back better. The road traverses through the Ramailo danda, Dhungre, Barnalu, Sanitar, Rumjatar. The proposed road is 11.100 km long.

The existing road starts from Ramailo danda of Siddhicharan Municipality-3 and ends to Rumjatar of Siddhicharan Municipality-13. Existing road surface is earthen and condition is moderate and undulated. Stone pitching also observed in some stretches of existing road. There are few minor landslides and erosion observed. The longitudinal grade is less than 12%. The existing road width of the alignment varies from 3m to 5m.

During the design, existing road has been followed as far as possible; however the alignment has been shifted in some places especially at loops to maintain the geometric design parameters and at problematic areas of steep gradient. Nepal Rural Road Standard (2055) 2nd revision, December 2014 has been followed for the design. The maximum and minimum grade adopted in the design is 12% and 0.5% respectively. The average grade of the whole road alignment is 7%.

Unnecessary heavy cut/fill has been avoided as far as possible. However, this could happen to some extent especially in loops, where the combined effect of design grade limitation and abrupt change of topography contour could induce such consequences and at sections with steep existing gradients. Bio-engineering works have been proposed in places prone to landslides and erosions. For spoil management, the proper locations along the site have been identified. For pavement design, CBR values have been calculated from the results of sub-grade material. 200 mm thick gravel sub-base, 150 mm thick base course and DBST have been proposed in design.

The design was reviewed during joint field verification by team of Consultant and CISC. The comments and feedback received by the consultants have been incorporated in preparing the final design.

The cost estimates are based on applicable DoLIDAR norms. In cases where DoLIDAR norms are not available, DOR norms have been used. The unit item rates for each item have been calculated on the basis of approved district rates of Okhaldhunga and Udayapur for fiscal year 2073/74. Rates of construction materials like cement, reinforcement, gabion, RCC pipes, HDP pipes etc are not mentioned in the district rate of Okhaldhunga, so that nearest and appropriate district (i.e. Udayapur) rates have been applied. While calculating item rates, it is assumed that a qualified contractor will undertake construction following mechanized approach for road works. The base cost of civil works has been estimated to be NRs. 222,783,567.03. The total cost for rehabilitation and reconstruction to DBST standard including VAT, contingencies consisting of work charge staff, small miscellaneous items and physical contingency as per GON rules is calculated to be NRs. 280,707,294.45. The per km cost including VAT is NRs. 22,679,768.54. It is envisaged that the construction works can be completed within 18 months from award of contract and estimates are based on it. For budgetary purpose to take account of change in scope in accordance with GON financial rules a provision of 10% of the base cost estimate has been indicated in the budgetary cost estimate.

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Features	**Description**
Name of the Road	Okhaldhunga – Rumjatar Road
DRCN Road Code	12DR016
Scope	Reconstruction and Rehabilitation
Location	
Region:	Eastern Development
Zone:	Sagarmatha
District:	Okhaldhunga
Municipality / VDC	Siddhicharan Municipality
Major Settlements	Ramailo danda, Dhungre, Barnalu, Sanitar, Rumjatar
Length	11.100 km
Starting Point	Ramailo danda, Siddhicharan Municipality
End Point:	Rumjatar, Siddhicharan Municipality
Beneficiaries Population in ZOI	16521
Geographical feature	
Terrain	Mid Hill
Altitudinal Range	1358 m to 1812 m
Climate:	Upper-tropical and Sub-tropical
Geology:	Basically characterized by Phyllite and Quartzite and the common soil types include colluvial and residual soils
Meteorology:	Unevenly Distributed Precipitation Controlled by Monsoon
Design Standard	
Standard	NRRS 2055, 2nd Revision December 2014
Existing Surface:	Earthen surface, Stone pitching etc.
Proposed Pavement:	Double Bituminous Surface Treatment (DBST)
Geometrics	
Right of Way:	10 m on either sides (Center line)
Formation Width:	5.25 m (excluding drain)
Carriage Way Width:	3.75 m
Shoulder Width:	0.75 m on either side
Maximum Gradient	12%
Minimum Gradient	0.5%
Lane	Single
Pavement Standard	DBST
DBST Length	11.100 km
Structures (Qty/No.)	

Features	Description
Drainage Structures	
a) Side Drain	13,302.91 m
b) Causeway	7
c) Slab Culvert	0
d) Pipe Culvert	37
Structures	
a) Stone masonry Work	6,837.14 m3
b) Gabion Work	8,695.25 m3
Earth Work	
a) Excavation / Cutting	80,830.17 m3
b) Embankment / Filling	7,699.17 m3
Pavement	
a) Sub Base	9,387.95 m3
b) Base Course	12,517.26 m3
c) Prime Coat	62,586.30 lit.
d) DBST	62,586.30 m2
Cost Estimate (NRs)	
a) Civil Works	Nrs. 222,783,567.03
b) VAT (13%)	Nrs. 28,961,863.71
c) Total Cost including Base Cost and VAT	Nrs. 251,745,430.74
d) Cost per KM	Nrs. 22,679,768.54
e) Work Charge Staff and Small Miscellaneous Expenses (3%)	Nrs. 6,683,507.01
f) Provision of Physical Contingency (10%)	Nrs. 22,278,356.70
g) Total Cost including Base Cost, VAT, Work Charge Staff and Small Miscellaneous Expenses and Physical Contingency	Nrs. 280,707,294.45

Figure 1: Map of Nepal showing Okhaldhunga District

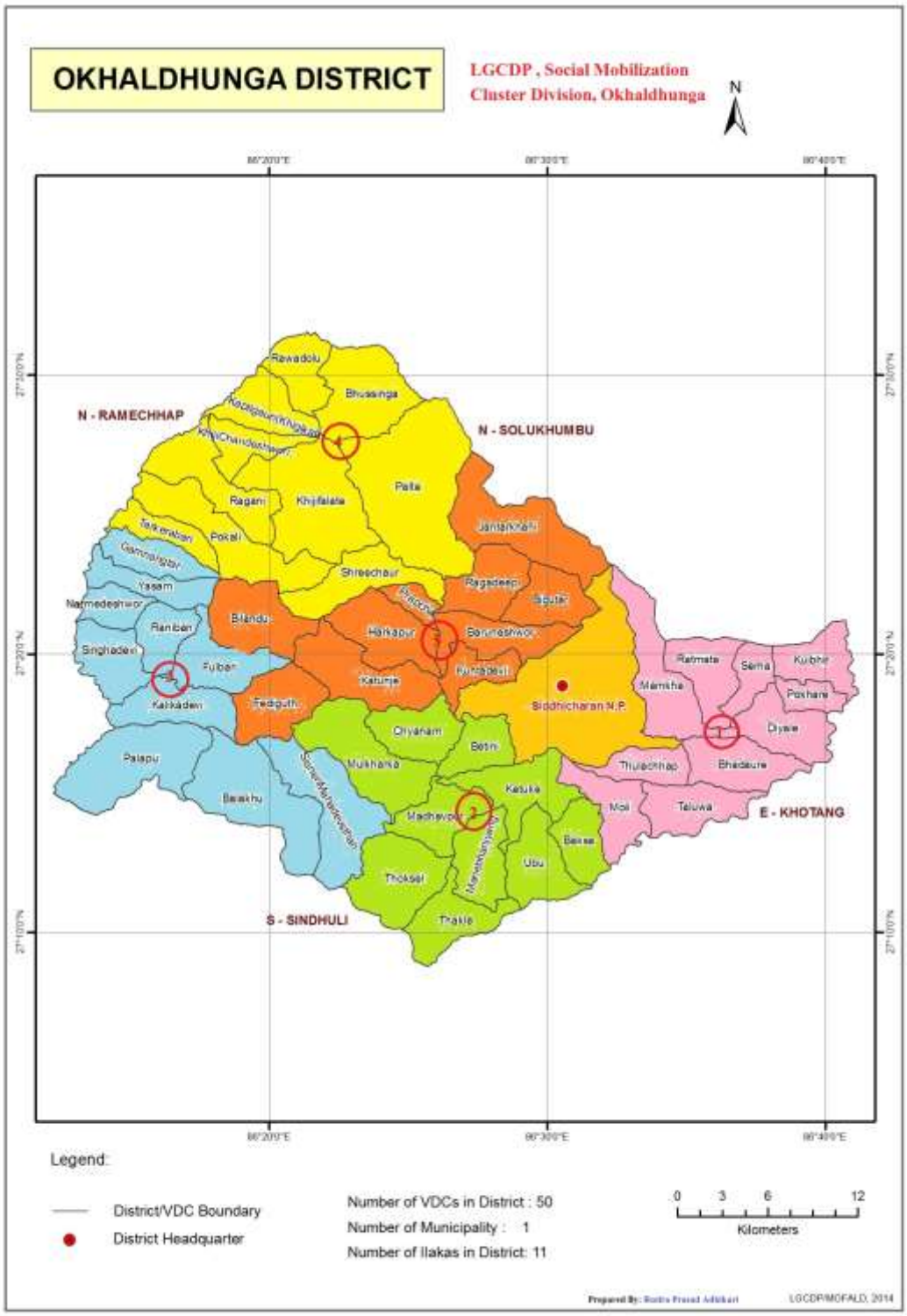

Figure 2: Map of District Okhaldhunga showing VDC Boundary

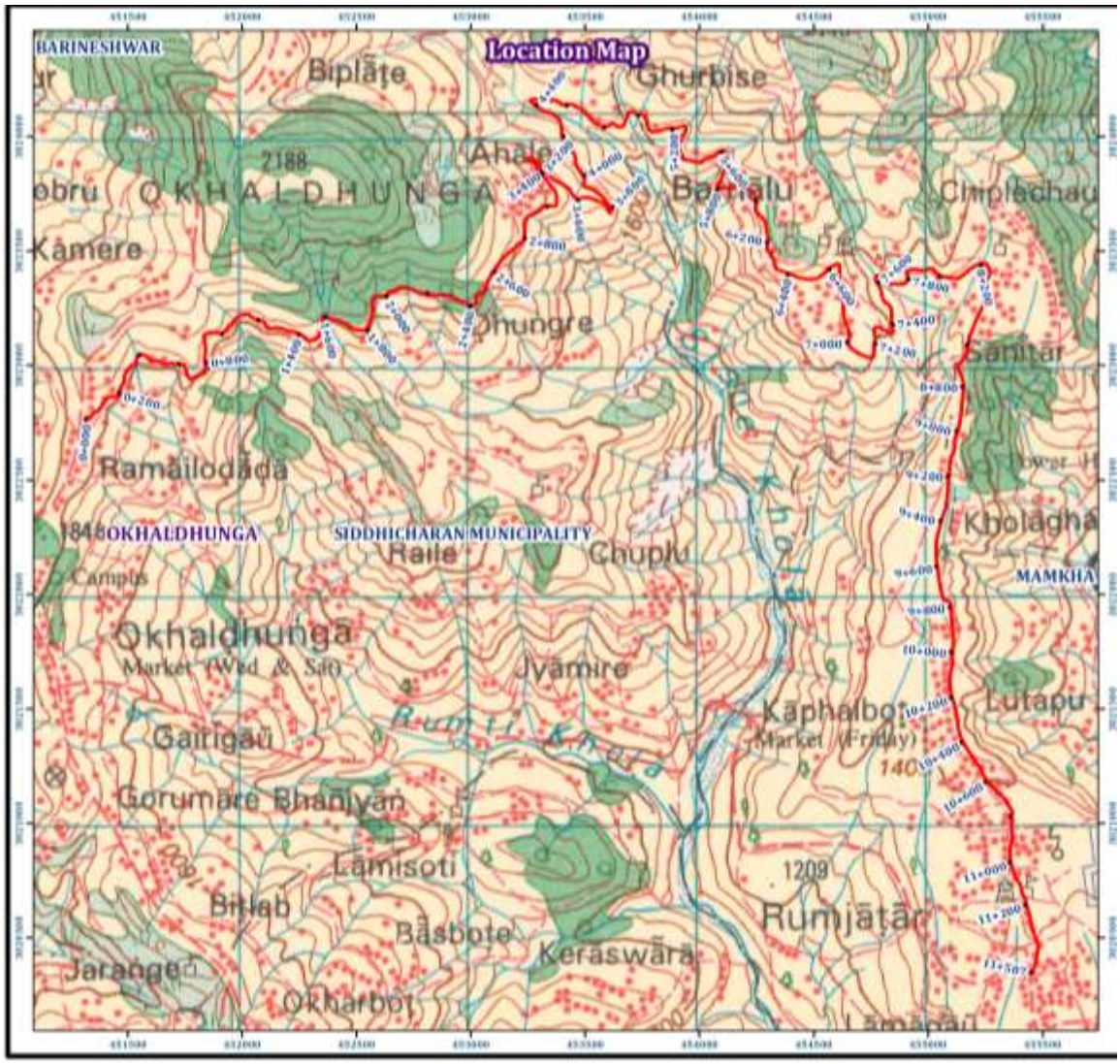

Figure 3: Okhaldhunga - Rumjatar Road Alignment

ACRONYMS/ ABBREVIATIONS

ADB	Asian Development Bank
ADDI	Appraisal Document for Donor Investment
BS	Baseline Survey
CISC	Central Implementation Support Consultants
CE	Community Empowerment
DDC	District Development Committee
DoLIDAR	Department of Local Infrastructure Development and Agricultural Roads
DRILP-AF	Decentralized Rural Infrastructure and Livelihood Project-Additional Financing
DoR	Department of Roads
DoS	Description of Services
DPR	Detailed Subproject Report
DRCN	District Road Core Network
DTMP	District Transport Master Plan
DTO	District Technical Office
EIA	Environmental Impact Assessment
EEAP	Earthquake Emergency Assistant Project
GDP	Gross Domestic Product
GoN	Government of Nepal
ICD	Institutional Capacity Development
IEE	Initial Environmental Examination
IPDP	Indigenous People Development Plan
IRR	Improved Rural Roads
LEP	Labor-based, Environmentally-friendly, and Participatory (approach)
LSGA	Local Self-Governance Act
MoFALD	Ministry of Federal Affairs and Local Development
RP	Resettlement Plan
ToR	Terms of Reference
VDC	Village Development Committee
VOC	Vehicle Operation Cost
ZoI	Zone Influence

CHAPTER - 1
INTRODUCTION

1.1 Project Background

The rehabilitation and reconstruction of local roads network damaged due to major earthquake of 25 April 2015 and May 12 2015 has high priority for the Government of Nepal (GoN). The Asian Development Bank (ADB) funded Earthquake Emergency Assistance by Project (ADB Loan 3260-NEP) is aimed to accelerate the recovery and reconstruction of the local roads damaged by the earthquake. The rehabilitation and reconstruction of about 385 km of rural roads damaged by the earthquake and landslides in 10 of the earthquake hit districts (Dolakha,Kavrepalanchowk, Laitpur, Chitwan, Sindhuli, Solukhumbu, Okhaldhunga, Ramechhap, Gorkha and Lamjung). Okhaldhunga - Rumjatar Road of Okhaldhunga district is one of the roads proposed for rehabilitation and reconstruction under EEAP.

AS part of the Technical Assistance from Swiss Agency for Development and Cooperation (SDC) also provided technical assistance to EEAP. AF-Iteco, Switzerland,currently providing services as Central Implementation Support Consultants (CISC) for Decentralized Rural Infrastructure and Livelihood Project-Additional Financing has been entrusted to act as Consultant for this project and has given the assignment for preparation of Detailed Project Reports for rehabilitation and reconstruction of selected 4 rural road subprojects of Cluster 3 (Solukhumbu, Okhaldhunga and Sindhuli Districts) to Joint Venture of SILT Consultants (P) Ltd, TSE, ECN, EC in association with Geocom International (P) Ltd.

1.2 Project District and Proposed Road

The Okhaldhunga – Rumjatar Road lies in Okhaldhunga district. Okhaldhunga, the project district, is located in the Sagarmatha Zone of the Eastern Development Region of Nepal. The district is located within 27° 08’ to 27° 32’ latitude and 86° 11’ to 86° 41’ longitude. The district borders with Sindhuli District in South, Khotang Districts in East, Ramechhap District in West and Solukhumbu in North. General records of Okhaldhunga district are as under:

Total area = 1,074 km2

Total population = 147,984 as per last census of 2011.

Total male = 68,687 as per last census of 2011

Total female = 79,297 as per last census of 2011

Total household = 32,502

Population density / km2 = 138

Literacy rate = 64.4 %

The road passes through the 5 major settlements (Ramailo Danda, Dhungre, Barnalu, Sanitar and Rumjatar) along the road alignment. During the site observation of existing road pavement, it was found the earthen and stone pitching surfaces in entire length. Existing road is motorable with 3m to 5m width. The road traverses through the various settlements, natural rivers / kholsi and forest.

Ramailo Danda

Shiva Temple near Road

Sisne Khola

Forest near Barnalu

Sanitar

Rumjatar Bazar

1.3 Scope of Works

The detailed engineering survey, design and cost estimate for rehabilitation and reconstruction. of Okhaldhunga – Rumjatar Road has been carried out by the Consultants.

Accordingly the scope of works covers:

c) Detailed engineering survey
d) Detailed design the road to DOLIDAR's NRRS 2055, 2nd Revision December 2014
e) Prepare drawings including alignment plan, design profile, design cross-section and typical drawings
f) Prepare detailed cost estimate
g) Prepare detailed project report (DPR)

CHAPTER -2

ENGINEERING SURVEY AND STUDY

2.1 Desk Study

During the process of desk study, the available reports and maps were collected and reviewed. All relevant guidelines, norms, specification were collected. Nepal Rural Road Standard (NRRS 2055) and DoLIDAR Norms & Specification has been studied and referred for adoption of design standard and specification.

2.2 Field Survey

After the desk study, engineering team comprising of highway engineer, surveyor and supervisor had been mobilized in field. The team contacted DTO office and with co-operation with staffs of DTO, the team mobilized to the site. The DTO team at Okhaldhunga assisted the survey team.

2.3 The Survey Team

The survey team for detailed survey work of Okhaldhunga - Rumjatar Road constitute of TL/Road Engineer, Civil Engineer, Surveyor and Labours.

The team members are: Mr. Prabhu Raj Pandey (TL/Road Engineer), Mr. Harish Thapa (Civil Engineer), Mr. Gokul Thapa (Surveyor) and Labours.

2.4 Topographical Survey

Survey Procedure

Detailed engineering survey was carried out for the design work of the road. The accuracy and effectiveness of design work depend on the accuracy of survey works, hence due care was given during survey works.

The fieldwork consists of detailed engineering survey of the project road. The linear traverse method was adopted for the survey and topographical survey was conducted for the proposed alignment. The topographic survey of the sites was carried out in detail using TOTAL STATION and survey points were recorded. It was ensured that the density of the survey points was adequate to prepare the detailed topography of the site. Contours were thus generated on scale 1:1000 with the details like contours at interval of 1m, channel bifurcation and merging points, survey control point, settlements/villages, utility services, etc.

The RL of center point of the cross section were measured using TOTAL STATION instrument readings. The observation of horizontal angles at each right and mean of two was done with both left and right faces and mean of two was used for calculation to eliminate errors due to eccentricity and centering. The TOTAL STATION instrument carried out profile leveling at an interval of 20 m and at all points where sudden changes of topography was observed. During the field works, all the data needed were recorded and registered.

BM was established where deemed necessary and fixed.

Instrument Station

During survey, the instrument was placed on the site from where forward and backward is clearly seen while taking maximum detailed points for detailing.

Bench Marks (BM)

In this study, the local coordinates and Benchmark values have been used. The bench marks are used as reference point during construction phase. At site, the benchmarks have been placed in permanent structures and the Benchmark numbers has been clearly written with enamel paints. (*Refer annex 01 for details of bench mark data).*

2.5 Topography and Geomorphology

2.5.1 Topography

The road alignment starts from the Ramailo Danda and ends at Rumjatar. The road alignment gently climbs down from Ramailo Danda and follows just below the ridge area. The road crosses Sisne Khola and other small tributaries which drain out into the Dudhkoshi River. The topography of along the road alignment is gentle slope. Because of the rock nature almost all road alignment has gentle slope.
The elevation of proposed road varies from 1358m to 1812m from mean sea level. The project area is located in sub-tropical climatic zone. The proposed project site falls under middle mountain physiographic region of Nepal (*Topographic Survey Branch, Department of Survey, HMG, Nepal, 1983*). The dominant rock types present in the Subproject area include Phyllite and Quartzite and the common soil types include colluvial and residual soils. Sisne Khola is the major stream of the project area.

2.5.2 Geomorphology

The road alignment follows the rocks of the Seti Formation, Midland Group, Lesser Himalaya. The Seti Formation is comprised of quartzite and phyllite.
The road alignment passes through the rocks of the Seti Formation. The Seti Formation is composed of thick phyllite and quartzite. Ratio of phyllite is greater than quartzite. This road alignment passes south of the thrust. The activation of the thrust is considered as minimal. The road alignment is located about 10 km south from the thrust.

Table 1: Lithostratigraphy of the Lesser Himalaya Rock Exposed along the Road Alignment

Group	Formation	Lithology	Thick (m)	Age
Main Central Thrust (MCT)				
Midland	Kushma	Phyllite, quartzite, limestone	1000	Pre-Cambrian
	Lakharpata	Limestone, dolomite	1000	
	Syangja	Slate, limestone, quartzite	1000	
	Galynag	Dolomite, slate	800	
	Naudanda	Quartzite,	1000	
	Seti *	Phyllite, quartzite	3000	

***Rock exposed along the road alignment**

Along the road section, the rocks of the quartzite and phyllite of the Seti Formation is also exposed along the road alignment. Road alignment is covered by the residual soil with thick colluvial deposits**.** More than 90% alignment covered by residual soil and colluvial deposits. Very few location bedrocks of phyllite can be seen along the road alignment.
Engineering Geological log is prepared based on distribution of failures, soil and rock along the alignment. Information covers depth of soil, rock and soil type, weathering grade. The road alignment passes through weathered phyllite and colluvial, residual soil deposits. Thickness of the colluvial and residual soil deposits are excess of 5 m.

Okhaldhunga - Ahale Section (0+000 - 3+400)

The road alignment is about 3.4 km in length and passes very gentle slope area along the ridge area. The road alignment runs on thick (more than 5 m thick) residual soil and colluvial deposits and very few locations covers the bedrock of phyllite. The hydrological condition of the road alignment is dry to wet. The land use pattern along the road alignment is dry cultivated land, forest and grassland but most of the alignment follows the dry cultivated land. There is very less chance to meet further cut slope failure due to low height cut slope and land use pattern. The bedrocks of phyllite of the Seti Formation are exposed along the road alignment but very few location bedrocks are exposed and covered by residual soil. The main cause of covering the residual soil deposits due to presence of the soft rock phyllite so these soft rocks easily weathered and formed the residual soil. The failures occurred along the road can be mitigated by trimming of cut slope, applying bioengineering as well as surface drainage, management and arrangement of the wall. The slope stability condition is more or less stable even the alignment runs on the residual soil deposits. Between the chainages road alignment has the low height cut slope on hill side so stability condition seems to be good.

Ahale – Sanitar Section (3+400 - 8+200)

This complete section of the road is about 4.8 km and is passing 90% on residual soil / colluvial deposits and 10% only in the rocks of the Lesser Himalaya (phyllite) and the Seti Formation of the Lesser Himalaya. The road follows very gently topography. Some cut slope failures are found along road alignment in hill side. These failures are developed due to weathering of rocks as well as presence of loose material deposits, undercutting slope by road cutting. Thickness of the residual soil deposits along the road section is more than 5 m at places. At some places of the road alignment phyllite is exposed. These rocks are slightly to highly weathered. Two to three sets of the joints are well observed in rocks exposed along the road alignment. The stereographic projection of the discontinuities of the rock mass

shows more or less stable condition. The persistency of the rocks mass is moderate to low. The hydrological condition is wet to dry to wet. The land use pattern is cultivated land and forest and settlement.

Sanitar – Rumjatar Section (8+200 -11+100)

This complete section of the road is about 4 km and is passing 90% on residual soil / colluvial deposits and 10% only in the rocks of the Lesser Himalaya (phyllite) and the Seti Formation of the Lesser Himalaya. The road follows gently topography. Cut slope failures are found along road alignment in hill side are developed in the soil. These failures are developed due to weathering of rocks as well as presence of loose material deposits, undercutting slope by road cutting. Thickness of the residual soil deposits along the road section is more than 5 m at places. At some places of the road alignment phyllite is exposed. These rocks are slightly to highly weathered. Two to three sets of the joints are well observed in rocks exposed along the road alignment. The stereographic projection of the discontinuities of the rock mass shows more or less stable condition. The persistency of the rocks mass is moderate to low. The hydrological condition is wet to dry. The land use pattern is dry cultivated land and forest and settlement.

Figure 4: Regional Geological Map of Okhaldhunga Area (DMG, 1987)

Table 2: Geology and Types of Soil along the Road Alignment

Chainage	Geology	Types of Soil
0+000 - 3+400	Soft rock phyllite	Residual soil / colluvial deposit
3+400 - 8+200	Phyllite, quartzite	Residual soil / colluvial deposit
8+200 - 11+100	Phyllite, quartzite	Residual soil / colluvial deposit

Table 3: Cutting and Filling Slope for Different Types of Geology along the Road

S.N.	Geological Classification		Slope Grade	
	Major Classification	Minor Classification	Cut Slope (V:H)	Fill Slope (V:H)
1	Soil	Colluviums Residual	1:2-1:1	1:1.5
2	Rock	Ordinary Medium	1:1/4-1:1/8 1:1/12-1:1/16	1:1.5
3	Rock	Hard	Almost Vertical	1:1.5

Source: Nepal Road Standard 2070

2.6 Vegetation Survey

Major forest types found in the project area is sub-tropical broadleaved forest dominated by *Schima-castanopsis* forest and *Alnus* forest. However, the proposed road is not situated in any national park, buffer zone or conservation area. The major plant species found along the proposed road alignment are Uttis, Chiluane, Chap, Katus, Nemaro, Khote Sallo, Malato,Lakuri, Dudhilo, Lali Guras, Jhigane etc. The main wildlife species found in project area are Ratuwa Mriga, Syal, Malsapro, Dumsi, Rato Bandar, Dhukur, Saru, Lampuchre, Luiche, Chibe, etc.

2.7 Construction Material Survey

Construction material investigation was carried out around vicinity of the project sites along the road alignment**.** The investigation focused on locating prospective borrows areas of non-cohesive materials (colluvial and alluvial deposits). The prospective borrow sites were identified as sources of coarse aggregates.

The construction material survey was carried out for the following purposes:

- Identification of location, estimation of quantity of sand, boulder, gravel and other possible construction material in and around the construction site.
- Site identification and determination of relevant materials available along river beds that can be used as concrete aggregates.

Based on the construction material survey, different quarry sites are observed along the road alignment as well as at river bank, possible quarry sites are shown below in table:

Table 4: Possible Quarry Sites

Material	Site	Average Distance
Sand	Sisne Khola, quarries within 10 km periphery	10 km
Stone	Sisne Khola, quarries along the road alignment and quarries within 10 km periphery	10 km
Gravel	Sisne Khola, quarries within 10 km periphery	10 km
Aggregates	Sisne Khola, quarries within 10 km periphery	10 km
SD Chips	Sunkoshi at Harkapur	87 km up to ch 0+000

The main source of construction materials is the Dudhkoshi River and Sun Koshi River But these sources are very far from the road alignment shall not be economically viable. The materials from quarry side is not possible along the road because the exposed rocks are phyllite some thin layer of quartzite can be seen but it is not economic and sufficient quantity. The volume of the construction materials is more than sufficient in quantity for the road construction. The possible areas are given in Table below:

Table 5: Sources of Construction Materials

S.N.	Source	Distance from Road Composition	Type of Extraction	Current Land Use	Borrow area Hydrology	Geological Instability
1	Sunkoshi River	Riverbed B-25%; C+P 60%; S-15%	Gneiss-70%; Quartzite and schist- 30%	Barren	1000x10x2 m^3	Stable
2	Tamakoshi River	Riverbed B-35%; C+P 50%; S-15%	Gneiss-80%; Quartzite and schist- 20%	Barren	1000x10x2 m3,	Stable

2.8 General Inventory

During the survey, retaining structures like gabion walls, gravity wall and breast wall along, several chainage were observed. During the design, priority has been given to protect the existing gabion walls as much as possible. Despite this, the retaining structures have to be dismantled while improving the grade of alignment as per NRRS.

During the inventory survey, following items / works were undertaken:

- Identification of locations for alignment improvement
- Identification of locations for intersection improvement
- Identification of locations and type of cross drainage and side drainage structures
- Identification of locations and type of stability structures
- Identification of locations and type of road safety structures
- Identification of environmental mitigation measures

During the inventory survey following retaining structures were observed along the road alignment listed as;

Existing Gabion Wall:

During the inventory survey, following gabion walls found in normal and workable condition. Minor repairing is required to make suitable with the design of the road.

Table 6: Existing Gabion Wall

S.N.	Chainage		Side	Length (m)	Height (m)	Remarks
	From	To				
1	0+030	0+038	LHS	8.00	2.00	Gabion Breast Wall
2	0+265	0+273	RHS	8.00	2.00	Gabion Ret. Wall
3	2+020	2+025	RHS	5.00	2.00	Gabion Ret. Wall
4	4+240	4+320	RHS	80.00	3.00	Gabion Ret. Wall
5	5+010	5+030	RHS	20.00	3.00	Gabion Ret. Wall
6	5+350	5+385	RHS	35.00	2.00	Gabion Ret. Wall
7	7+330	7+435	LHS	105.00	2.00	Gabion Breast Wall
8	7+550	7+585	RHS	35.00	3.00	Gabion Ret. Wall
			Total	**296.00**		

Following existing gabion walls are to be demolished due to the poor quality as well as not suitable with the design of the road.

Table 7: Existing Gabion Wall to be demolished

S.N.	Chainage		Side	Length (m)	Height (m)	Remarks
	From	To				
1	1+475	1+480	RHS	5.00	2.00	
2	2+120	2+130	RHS	10.00	2.00	
3	2+180	2+200	RHS	5.00	2.00	
4	3+130	3+165	LHS	35.00	3.00	
5	3+610	3+660	RHS	50.00	3.00	
			Total	**105.00**		

Existing Stone Masonry Wall:

During the inventory survey, following stone masonry walls found in normal and workable condition. Minor repairing is required to make suitable with the design of the road.

Table 8: Existing Stone Masonry Wall

S.N.	Chainage		Side	Length (m)	Height (m)	Remarks
	From	To				
1	1+000	1+002	RHS	2.00	1.00	SM Ret. Wall
2	1+225	1+235	RHS	10.00	2.00	SM Ret. Wall
3	2+430	2+610	RHS	180.00	2.00	SM Ret. Wall
4	2+650	2+710	RHS	60.00	2.00	SM Ret. Wall
5	5+930	5+955	RHS	25.00	1.00	SM Ret. Wall
6	10+405	10+500	RHS	95.00	1.00	SM Ret. Wall
			Total	**372.00**		

Following existing stone masonry walls are to be demolished due to the poor quality as well as not suitable with the design of the road.

Table 9: Existing Stone Masonry Wall to be demolished

S.N.	Chainage		Side	Length (m)	Height (m)	Remarks
	From	To				
1	1+780	1+800	RHS	20.00	2.00	
2	3+220	3+250	RHS	30.00	2.00	
			Total	**50.00**		

2.9 General Alignment Description

The Okhaldhunga – Rumjatar Road alignment lies in the hilly region of Nepal. The road alignment starts from Ramailo danda, Siddhicharan municipality and passes through various villages to end point Rumjatar. The total length of the road is 11.123 km and existing width varies from 3m to 5m. However in new design, the proposed road width shall be 5.25m except at extra widening, passing places and bus bays area.

2.10 Land Use Pattern

The project road traverses from Ramailo Danda to Rumjatar through the settlement area, forest, barren land, cultivated land etc.

Table 10: Land Use along the Road Alignment

Chainage	Land Use Pattern
0+000 to 3+400	Dry cultivated land, forest, grassland etc
3+400 to 8+200	Cultivated land, forest, settlement etc
8+200 to 11+100	Dry cultivated land, forest, settlement etc

2.11 Passing Bays and Bus Lay Bys

In general, passing bays are located at interval of 300m following the NRRS (2055) 2nd revision December 2014 and bus lay bys location are fixed along nearby major settlements. However, ensuring proper visibility and to minimize the maximum cut/fill due to extra width governed, the location of passing bays are shifted at several locations which do not comply the NRRS.

Table 11: Passing Bays

S.N.	Chainage	Length (m)	Width (m)		Transition Length (m)
			LHS	RHS	
1	0+430	12.00		1.75	9.00
2	0+710	12.00		1.75	9.00
3	1+160	12.00		1.75	9.00
4	1+365	12.00	1.75		9.00
5	1+500	12.00		1.75	9.00
6	1+915	12.00		1.75	9.00

S.N.	Chainage	Length (m)	Width (m)		Transition Length (m)
			LHS	RHS	
7	2+230	12.00		1.75	9.00
8	2+700	12.00		1.75	9.00
9	2+831	12.00		1.75	9.00
10	3+100	12.00		1.75	9.00
11	3+600	12.00	1.75		9.00
12	4+185	12.00		1.75	9.00
13	4+560	12.00	1.75		9.00
14	4+930	12.00	1.75		9.00
15	5+255	12.00		1.75	9.00
16	5+600	12.00	1.75		9.00
17	5+950	12.00		1.75	9.00
18	6+231	12.00		1.75	9.00
19	6+520	12.00	1.75		9.00
20	7+050	12.00	1.75		9.00
21	7+430	12.00		1.75	9.00
22	7+700	12.00	1.75		9.00
23	8+000	12.00		1.75	9.00
24	8+260	12.00		1.75	9.00
25	8+610	12.00	1.75		9.00
26	9+150	12.00	1.75		9.00
27	9+450	12.00	1.75		9.00
28	9+820	12.00		1.75	9.00
29	10+030	12.00	1.75		9.00
30	10+220	12.00		1.75	9.00
31	10+715	12.00	1.75		9.00
32	10+910	12.00		1.75	9.00
33	11+060	12.00	1.75		9.00

2.12 Cross Drainage and Irrigation Crossing

Depending upon the nature of road profile, type of natural drainage system, pipe culverts, causeways and slab culverts are proposed at different sections which are as under:

Pipe culvert (900 mm dia.) = 3 nos

Pipe culvert (600 mm dia.) = 29 nos

Pipe culvert (300 mm dia.) = 5 nos (provisional)

Causeway = 7 nos

Table 12: Proposed Pipe Culverts

S.N.	Chainage	Diameter (900 mm)	Diameter (600 mm)	Diameter (300 mm)	Remarks
1	0+100		1		
2	0+370		1		
3	0+822		1		
4	0+965		1		
5	1+000		1		
6	1+072		1		
7	1+928		1		

S.N.	Chainage	Diameter (900 mm)	Diameter (600 mm)	Diameter (300 mm)	Remarks
8	2+142		1		
9	2+745		1		
10	3+140		1		
11	3+425		1		
12	3+665		1		
13	3+800		1		
14	4+415	1			
15	4+565		1		
16	5+028	1			
17	5+373	1			
18	5+585		1		
19	6+198		1		
20	6+415		1		
21	6+900		1		
22	7+650		1		
23	7+940		1		
24	8+365		1		
25	8+590		1		
26	8+970		1		
27	9+305		1		
28	9+665		1		
29	10+050		1		
30	10+310		1		
31	10+670		1		
32	11+070		1		
	Total	**3**	**29**	**5 (provisional)**	

Table 13: Proposed Causeways

S.N.	Chainage	Length (m)	Remarks
1	1+477	15.00	
2	1+815	15.00	
3	2+030	12.00	
4	4+225	15.00	
5	4+270	30.00	
6	4+753	20.00	
7	7+353	15.00	

2.13 Retaining Structures

Retaining structures are designed to restrain soil to unnatural slopes and are used to those areas where landscape of the lands needs to be reshaped. Stone masonry walls and gabion walls are proposed based on their appropriateness.

Gabion Masonry Wall

Based on the suitability of the kind of structures, gabion walls are proposed for high cut slopes and terraces, where higher walls are required. Also, the walls are proposed on the areas having poor foundation and seepage condition due to its flexibility for certain differential settlement and some slope movements. Besides, the wall is proposed on the hill sides to restrain against slope movement at landslide zones.

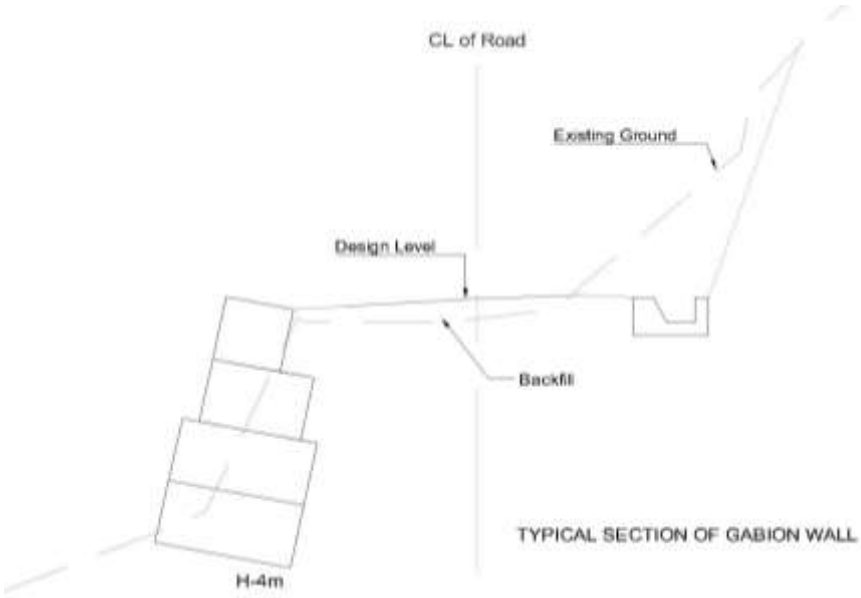

Figure 5: Typical Road Cross Section Showing Gabion Wall

Stone Masonry Wall

Stone Masonry gravity walls are designed on the valley side where the road section becomes narrow due to existing settlement to both sides. Besides, the walls are designed to the locations where rocks exists beneath the foundation as well as the wall is designed where the height of wall do not exceed more than 3m. For the slope and foundation width of the wall, DoLIDAR approach manual, Overseas Road Note 16, DRSP and RAIDP manual is followed.

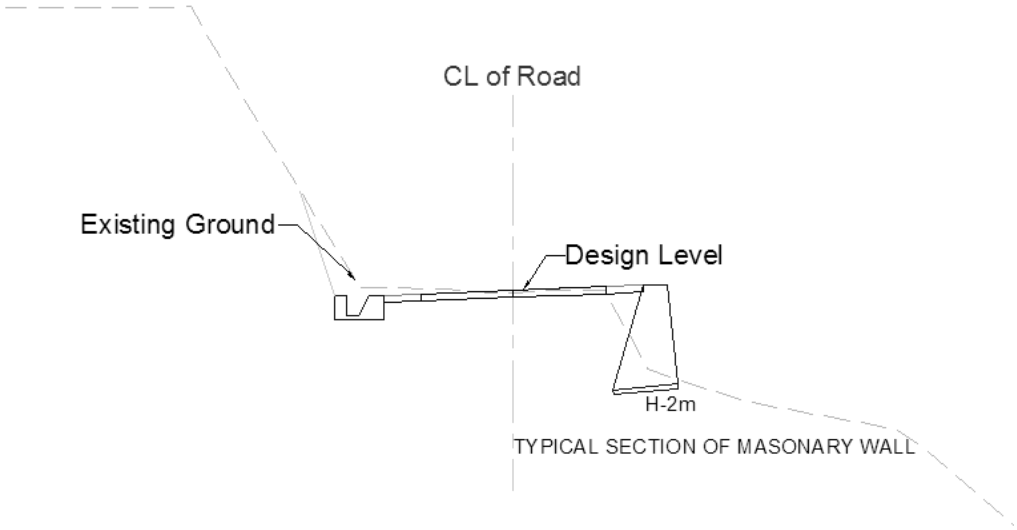

Figure 6: Typical Road Cross Section Showing Stone Masonry Wall

2.14 Traffic Safety Measures

Traffic safety measures are important component for roads. Traffic safety is important to reduce the chance of accident occurring. For prevention of serious accidents in hill roads, safety barriers are essential. The delineator posts at the loops and steep valley slopes are significant for traffic safety purpose.

2.15 Data Entry and Analysis

After the completion of topographical survey, confirmation was done ensuring the density of points is enough to produce contours at an interval of 1m. For some areas re-survey were done at the same time to increase the density of point to fill some voids. The data recorded in total station were extracted in excel sheet and with the help of SW-DTM inbuilt with Auto CAD, the data were processed. During this time, the redundant data were first eliminated from the list and final contour was drawn.

Likewise, the existing road centerline and road edges were plotted on the contour with the help of SW-DTM. For the design of new alignment, profile and road width, SW-Road was used with necessary changes in alignment on the existing road alignment

CHAPTER -3

ROAD CORRIDOR COMMUNITY PROFILE

3.1 VDCs Along Road Corridor

The proposed Okhaldhunga – Rumjatar Road passes through the Siddicharan Municipality ward No. 1, 2 and 3, Siddichran Munucipality 12 and 13, and then Barnalu VDC-1 and then Rumjataar VDCs of Okhaldhunga District of Eastern Development Region of Nepal. The Earthquake Emergency Assistance Project (EEAP) has proposed to upgrade the 11+123 km section of the road. The road section starts from Okhaldhunga Bazaar, Ramailo Danda of Siddicharan Municipality, Ward No. 7 along Okahldhunga-Solukhumbu Road and ends at Rumjataar airport, passing via more than 10 settlements along the alignment. The major settlements along the road alignment are ward no 1,2 and 3 of Siddicharan Municipality, sanitar, Ward no 12 and 13 of Siddicharan Municipality, then Barnalu VDC ward no. 1 and rumjatar bazaar. The road connects only airport of the Okhaldhunga District which is at Rumjatar and other eastern part of Okhaldhunga district with the district headquarter in Okhaldhunga and rest of the country through Siddicharan Highway through all-weather connectivity.

Table 14: Demographic Features of Influenced VDCs

Sn.	Influenced Municipality	Total HHs	Total Population
1.	Siddicharan Municipality	3739	16521

Source: Census 2011, Central Bureau of Statistics, Nepal

Table 15: Gender and Ethnic Features of the VDCs along the Road Corridor

S.N.	Influenced Municipalities and VDCs	Male Population	Female Population	Indigenous Population	Dalit Population	Total Population
1.	Siddicharan Municipality	8509	8012	9638	1456	16521

Source: Census 2011, Central Bureau of Statistics, Nepal

3.2 Cast Ethnicity

The population of the project area is dominated by indigous people (58.34 %) followed by Brahmin-Chhetri (32.85%) and dalit (8.81 %). The indigenous people of the area is consisted of Rai, Guring, Newar, Tamang, Magar, Sunuwar, Sherpa, Bhujel, and some Limbu. The area is a home to diverse ethinic or indigeneous communities like Newar, Tamang, Sherpa, Gharti/Bhujel and Magar and occupational casetes like Damai, Kami, Sarki.

3.3 Occupation

The people here have major occupation as agriculture and livestock farming which contribute almost half of the district's economy. People depend on subsistence agriculture, however more than three quarter of the population in the area cannot meet their subsistence requirements for their small size of land holdings. According to the study conducted by Swiss Development Agency

(2008) there are 25%-50% households which produce just sufficient for 6 months. They rear goat, pig, poultry and buffaloes for household use. They visit out of their village for wage labour and some of them, like all other castes, have been in foreign land for better earning. Occupational caste households are distributed in almost all the settlements. They have the lowest status in all sectors, i.e. they lack land resources, livestock, education, sufficient income, access to all services and facilities. The major cereal crops grown here are maize, wheat and millet. The cash crops grown are potato and oil seed.

3.4 Education and Health Status

Considering the population above 5 years of age, the total literacy of the project VDCs is 52.1% with male literacy rate 62.8% and female literacy rate 40.9%. The literacy of project VDCs is comparable with that of the whole district. Project area has people with all levels of academic achievements. Recently, the district has been declared completely literate district and District Education Office (DEO) has been implementing informal education programmes to achieve cent percent literacy rate. Local people have realized the importance of education in their life and most of them send their children to school. However, dropout rate of female students is still higher than male students.

Health care service is being delivered by two hospitals. One community hospitals at Okhaldhunga and one district level hospital at Rumjatar with 47 beds are along the road alignment.. Similarly there is one Aaurved Health Centre and three district aurved medicine centres in the district headquarter. According to the District Health Office (2072), the major health problems of the area are pulmonary obstructions/respiratory tract infection, skin diseases, diarrhea, gastritis, ear infection, helmenthiasis, typhoid and others. The health status of people has improved because of increased awareness towards health and sanitation.

CHAPTER - 4

DESIGN STANDARD AND PARAMETERS

4.1 Geometric Design Standard

The geometric design standards and parameter are strictly followed from NRRS published by DoLIDAR 2nd Revision December 2014, with the salient features, as outlined in the table below. The design standards adopted for the upgrading of the road are that of fair weather earthen road with low traffic volume. The roads can be upgraded in a compatible manner as the traffic volume increases and availability of resources justify additional inputs.

Table 16: DoLIDAR Standard

S. No	Road Components	Design Standards	Remarks
		Hills	
1.	**Carriageway Width (m)** • Traffic < 100 VPD • Traffic>100VPD<400VPD	3.00 3.75	
2.	**Shoulder Width (m)**	0.75	On both sides
3.	**Roadway Width (m)** • Traffic < 100 VPD (see notes below) • Traffic>100VPD<400VPD	4.50 5.25	Excludes width of drain, parapet & retaining wall top
4.	**Right of Way (m)**	20.00	10m RoW on either side from the road centerline
5.	**Design Speed** • Ruling • Minimum	25 20	
6.	**Stopping Sight Distance (m)**	20.00	
9.	**Radius of Horizontal Curves (m)** • Ruling • Minimum	≥20.00 12.50	
10.	**Hairpin Bends**		

S. No	Road Components	Design Standards	Remarks
		Hills	
	Desirable Spacing (m)	100	100 m spacing is desirable but may be less as per site condition.
	Minimum Radius (m)	12.5	Exceptional Case: 8.5m
	Minimum Roadway width at apex(m)	5.5	For curves with radius <12.5m provide 7.00 width
11.	**Gradient (%)**		
	Ruling	7	
	Limiting	10	
	Exceptional	12	Up to 15% in hill roads for short stretch of 50m in unavoidable situation except in hairpin bends.
	Maximum for Bridge approach	6	
	Minimum in hill roads	0.50	
12.	**Extra Widening (m)**		
	For curve radius ≤ 20m	1.5	
	For curve radius 20 -60 m	0.60	
	For curve radius > 60 m	Nil	
13.	**Camber Minimum (%)**		
	Earthen Roads	5	Hills: Unidirectional camber sloping either towards hill side or valley side
	Gravel Roads	4	Hills: Unilateral camber in carriageway sloping towards hill side
	Bituminous Roads	3	Hills: Unilateral camber in carriageway sloping towards hill side
14.	**Passing Zone/Bus Lay Byes**	**Passing zones:** width of carriage way width 5.5m and length about 12 m along outside edge and 30 m along inside ie. Towards the carriageway side and each end tapered gradually towards the carriageway. **Bus Lay Bys**: minimum width additional 3 m (ie. total minimum carriageway width is 6m) and and length about 12 m along outside edge and 30 m along inside ie. Towards the carriageway side and each end tapered gradually towards the carriageway.	
15.	**Traffic Signs and Road**	As detailed in the NRRS 2013	

S. No	Road Components	Design Standards	Remarks
		Hills	
	Safety		
16.	**Carriageway Width (cross-drainage structures)**		
	Culvert	6.50	Distance between parapet walls
17.	**Road Side Drains**	**Hill roads:** trapezoidal stone masonry drain (1:4) of size 1mx0.5m through-out the road length as required **Built up areas:** Drain as specified in DoLIDAR Technical Guideline with adequate cover slabs for crossings.	
Surfacing Options			
1.	**DBST Surface**	**Hill roads :** 150 mm gravel sub-base, 200 mm base course and DBST Surface	

CHAPTER - 5

ENGINEERING DESIGN

The design parameters adopted for Okhaldhunga – Rumjatar Road follow DoLIDAR Nepal Rural Road Standard (2055), 2nd Revision December 2014.

5.1 Road Classification

The proposed road has been classified as District Road Core Network (DRCN) and assigned Code No. is 21DR025.

5.2 Design Speed

The design speed has a crucial role in geometric parameters of the roads. The design speed depends on various factors like; super elevation, sight distance, radius and length of horizontal curve, extra widening of pavement, and the length of vertical curve (summit and valley) etc. According to the design standards followed, the ruling design speed adopted 25km/hr in flat section. However at hairpin bends, horizontal curve and steep sections, the adopted design speed as per NRRS is 20km/hr.

5.3 Right of Way

As per the design standard of DoLIDAR, right of way adopted for Okhaldhunga – Rumjatar Road is 10 m either side.

5.4 Roadway Width

Roadway width adopted for the proposed road is 5.25m. It includes 3.75 m width Carriageway width and 0.75m of shoulder on either side.

5.5 Extra Widening

It is necessary to widen the carriage way at sharp horizontal curves for the free movement of vehicles. Only mechanical widening has been proposed to compensate the extra width occupied by the vehicle on the sharp curve. For this, the inner part of the curve is proposed for widening as per NRRS as listed below in table.

Table 17: Extra Widening

SN.	Radius		Extra widening (m)
	From	To	
1	0	20	1.5
2	20	60	0.6
3	60	1000	0

5.6 Sight Distance

Since, the road is located in hill area; stopping sight distance must be secured properly. In this project, a minimum of 20 m is secured for design speed 20 km/hr and 25 m is secured for the flat section having design speed of 25 km/hr.

5.7 Horizontal Curvature

In each intersection, points are provided. As per the DoLIDAR Standards, the minimum radius of horizontal curve is taken as 12.5m.

5.8 Vertical Curvature

Vertical curves are provided as per the NRRS of DoLIDAR standard.

5.9 Longitudinal Section

A general minimum gradient of 0.5% was adopted in very flat conditions. Maximum grade of 12% permissible as per the DoLIDAR Standard was adopted. The gradient at loop should be up to 4% but due to geography of the alignment at loops, this gradient of 4% is difficult to maintain. However, the grade permissible by the design guidelines is maintained.

5.10 Pavement Surface

DBSD pavement surface has been proposed for the entire alignment of the road. Structure of pavement is as under:

200 mm thick gravel sub-base

150 mm base course

Double Bituminous Surface Dressing

5.11 Cross Section

The cross section at every 20m chainage point was considered to obtain the existing ground condition. The cross section design was carried out taking plan and profile under consideration.

5.12 Passing Bays and Bus Lay Bys

For passing bays, width of carriage way width is 5.5m and length about 12 m along outside edge and 30 m along inside i.e. towards the carriageway side and each end tapered gradually towards the carriageway. For bus lay bys, minimum width is additional 3 m (i.e. total minimum carriageway width is 6m) and and length about 12 m along outside edge and 30 m along inside i.e. towards the carriageway side and each end tapered gradually towards the carriageway. The passing bay and bus lay bys has been proposed in such a way that no additional retaining structure is required.

5.13 Water Management Measures

An utmost consideration is given to water management during design and their estimate. Depending upon the nature of existing natural channel and road profile, appropriate cross drainage types are proposed for water management. For this, pipe culverts, slab culverts, causeways and irrigation crossings are proposed in along the road as per need.

For surface water management, side drainage towards hill side with varying sizes are proposed along the whole road stretches and the hill side camber principle is adopted for proper management of surface water. The minimum size of cross drainage adopted pipes of 600 mm except for irrigation channel. For crossing of irrigation channel, the minimum diameter of pipes proposed is 300mm.

5.14 Side Drains

Side drains are required to prevent structural damage to the road. The water collected from surface runoff is required to be collected and drain off from nearby rivulet, culverts or cross drainage to protect the exiting road structures. For this, different kinds of side drains could be used as appropriate.

In this project, stone masonry trapezoidal type side drainage is proposed along the whole stretches towards hill side since the road is designed with only one camber slope towards hill side. Both side cambers have been provided only at the settlement / market area. The total width of drainage proposed is 1m in width and depth 0.5m. In some stretches, the depth of drainage varies up to 1.0m as per site requirements. Also, covered type side drain has been proposed in settlement/ market area. The size of the cover is proposed as 1.0X0.50X0.15m. Further, cascade type side drainage is proposed along the road stretches having its gradient greater than 5%. The typical drawing for side drains isincluded in Volume 3 drawings.

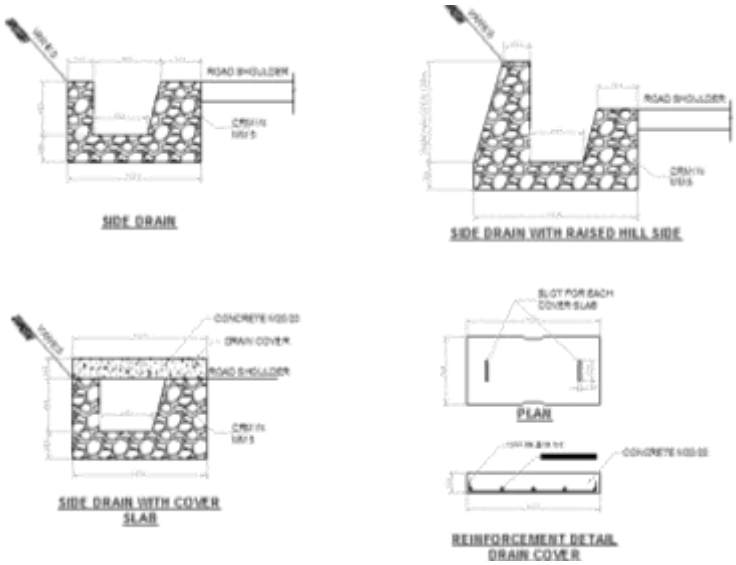

Figure 7: Proposed Typical Drain

5.15 Pavement Design

The road from Okhaldhunga - Rumjatar is proposed building back better under DRLIP-AF, i.e, one step better than the existing condition. At present the road is graveled starting from Okhaldhunga up to approximately Ch 5+600. From Ch 5+600 onward cobble/boulder soling were laid. The width of paved road is approximately 3.0m. Visualizing the importance of road, Okhaldhunga - Rumjatar road is proposed to upgrade and improve to bituminous surfacing standard. Road pavement is most important component of highway. Therefore the overall functioning of highway system is greatly relying on the performance of its pavement. The flexible pavement design is governed by several factors such as traffic, wheel load, climate, terrain and sub grade condition. Road pavements are designed for certain duration of time (Design life) considering the influencing factors mentioned above. The design life does not mean that at the end of period the pavement will be completely worn out and in need of reconstruction; it means that the towards the end of period the pavement will need to be strengthened so that it can continue to carry traffic satisfactorily for a further period.

Pavement design for Okhaldhunga - Rumjatar road is carried out as per guide lines recommended in “Pavement Design Guidelines(Flexible Pavement)”,Planning, Monitoring and Evaluation Unit, DoR and Road Note 31(TRL,UK).

Sub-grade:

The sub grade in cut or fill should be well compacted to utilize its full strength and to economize on the overall thickness of the pavement required. The strength of road sub grades is commonly assessed in terms of California Bearing Ratio (CBR) and this is dependent on the type of soil, its density and its moisture content. Since soil type varies from section to section along road alignment, sub grade CBR also varies from section to section. Besides that with construction point of view, it is not convenient and difficult to construct a road with varying pavement thickness in small road sections. Therefore well compromise should be made between these two aspects. Hence visualizing the type and nature of sub grade material, section with similar sub grade material should be identified and effective sub grade strength should be assessed for pavement design of this section. The identified section should also be ease with construction point of view.
The Sub grade strength of proposed road was assessed by California Bearing Ratio (CBR) test at laboratory. The representative sub grade materials from selected location are extracted for laboratory test. Proctor (Heavy compaction) test was carried out in collected sub grade in order to determine maximum dry density and optimum moisture content. The soaked CBR test was carried out in all collected sub grade materials. The corresponding CBR value at 95% of MDD is derived. Road pavement design on lowest sub grade CBR value is not economical. For design purposes it is important that the strength of the sub grade is not seriously underestimated for large areas of pavement or overestimated to such an extent that there is a risk of local failures. As recommendation made in RN 31, the best compromise for design purposes is to use the lower ten percentile value i.e. that value which is exceeded by 90 per cent of the readings.

The ten percentile value of CBR test results in Okhaldhunga - Rumjatar road is 10.0%. Hence, the adopted sub grade CBR value for the pavement design is 10.0%. According to RN 31 sub grade materials of this road falls in S4 (8% to 14% CBR value) class.

The lab test reports of Maximum Dry Density (MDD) and CBR test are attached in relevant appendix and summary of test results are tabulated in the following table.

Table 18: Laboratory CBR Test Results

S.N.	Chainage	MDD	OMC	CBR at 95 % MDD
1	0+500	1.920	11.40	12.60
2	2+650	1.852	11.70	11.60
3	4+000	1.980	8.70	14.80
4	5+450	2.040	9.00	16.70
5	7+850	2.020	8.60	21.00
6	11+050	1.776	12.99	8.40

Traffic:

The loading and type of vehicle that will use the road plays a vital road in pavement design. Hence the prediction of traffic volume anticipated during pavement design life is essential for pavement design. Road pavement failure is mainly due to traffic movement both from the magnitude of the individual wheel loads and the numbers of times these load are applied. The loads imposed by passenger cars do not contribute significantly to the structural damage of the pavement. Vehicles that should be considered for pavement design are defined as those having an unladen weight of 3000kg or more. The total number of anticipated commercial vehicles during design life is converted in to the cumulative equivalent standard axle of 8160 kg.

The local concerned authorities were consulted for the prediction of expected traffic in Okhaldhunga - Rumjatar road. The road is assumed to be built after 2 years and comes in operation. Analyzing the information and suggestions provided the expected traffic at the opening of road after construction is assumed as follows:

Table 19: Traffic Type and Volume

S.N.	Vehicle Type	No per Day Both Way	Remarks
1	Bus	14	
2	Multi Axle Truck	6	
3	Truck/Tipper	24	
4	Tractor	30	
5	Jeep	40	
	Total	114	

Due to lack of sufficient information the traffic growth rate and vehicle damaging factor are adopted as recommended in "Pavement Design Guidelines (Flexible Pavement)", Planning, Monitoring and Evaluation Unit, DoR.

With this assumption cumulative number of traffic for the period of 10 years is calculated initiating from the time of proposed road operation. The following formula is used for calculating the traffic volume in different years.

$A = P \times (1+r)^{n}$

Where,

A= traffic at the end of n years

P= present volume of traffic

r= growth rate

n= no. of years

The cumulative traffic projected for the design period of 10 years and corresponding cumulative equivalent standard axle is presented in the following table.

Table 20: Cumulative number of commercial vehicles and equivalent standard axle at the end of design period (10 years)

S.N.	Description	VDF	Cum Traffic	esa	Remarks
1	Bus				
	Big	0.5	7.06E+04	3.53E+04	
2	Truck				
	Multi Axle	6.5	3.03E+04	1.97E+05	
	Heavy	3.5	1.21E+05	4.24E+05	Hill Road
3	Tractor	1	1.51E+05	1.51E+05	
			Total	8.07E+05	

Flexible Pavement Design:

Hence, according to chart 1of Road Note 31for cumulative equivalent standard axle of 0.8 x 10^6 esa(T3 - 0.7 x10^6 to 1.5x10^6 esa), the pavement thickness required is;

S4/T3 class – Traffic 0.7 x10^6 to 1.5x10^6 esa and CBR value of 8 to 14%;

Sub-base with 30% min. CBR	-	150 mm
Base course with 80% min. CBR	-	200 mm
Surface Dressing (DBST)	-	Yes

Total		350 mm

Recommendation and Conclusion:

Based on pavement design analysis guidelines recommended in TRL, Road Note 31 and usual practice followed in different projects of DoR and DoLIDAR following recommendations are concluded for Okhaldhunga - Rumjatar Road Project:

- The estimated traffic during the design life of the road is 0.8 x 10^6 esa and this falls in the lower limit of T3 class. Hence based on the experience of consultant in such roads we recommend following pavement thickness for the proposed road.

Sub-base with 30% min. CBR	-	150 mm
Base course with 80% min. CBR	-	200 mm
Surface Dressing(DBST)	-	Yes

Total		350 mm

- For quality assurance plan and material specification it is recommended to follow the standard specification of Road and Bridges, DoR.
- Sub grade formation level should be compaction according to requirements mentioned in specification.
- Base course and sub base materials should comply with the requirements mentioned in specification, DoR. The CBR value of 80% and 30% are recommended for base course and sub base materials respectively.
- 14mm nominal size aggregate is recommended for 1st coat of DBST and 6mm nominal size aggregate is recommended for 2nd coat of DBST.
- 80/100 penetration or equivalent bitumen is recommended for binder.
- For DBST work, recommendation and guidelines out lined in Road Note.3 is recommended to follow.

CHAPTER - 6

ENGINEERING DESIGN AND DRAWINGS

The engineering design is prepared based on Nepal Rural Road Standards published by DoLIDAR. Despite this at some locations, the design differed with the guidelines set by DoLIDAR due to the nature of topography, settlement and local issues.

The engineering drawings are prepared with the use of Auto CAD as drafting tools. In drawings, plan profile and cross-sections are published and presented for the whole length of road. However, for the road structures like; passing bys, retaining walls, cross drainage, side drains, traffic safety etc. only typical standard drawings with necessary detailing are shown in drawings. For scaling of the drawing, given ToR and standard practices are followed. All required drawings are placed in "Volume3: Design Drawing". Some typical sample of plan, profile and sections are placed below

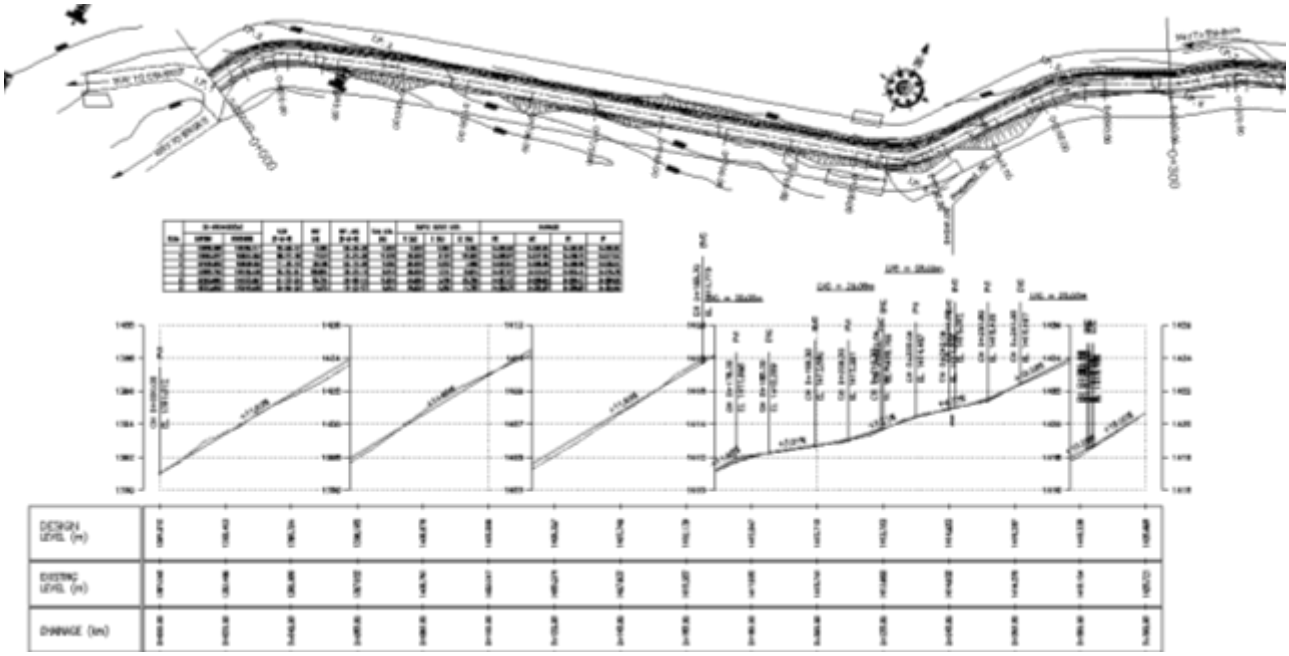

Figure 8: Sample Sheet of Plan and Profile

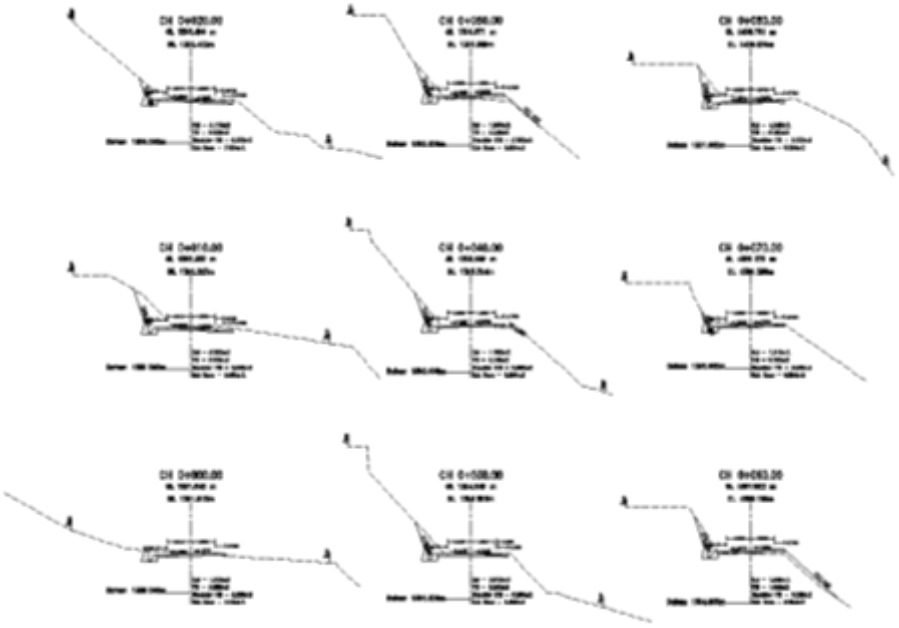

Figure 9: Sample Sheet of Cross Sections

CHAPTER - 7
ENGINEERING ESTIMATE

7.1 The Project Cost Estimate

The cost of the project has been worked out based on the quantity estimate and rates of work items. The detailed project cost estimate has been provided in Volume 2: Cost Estimate. The cost of civil works has been estimated to be Rs. 222,783,567.03. The total cost for rehabilitation and reconstruction to DBST standard including VAT, contingencies consisting of work charge staff, small miscellaneous items and physical contingency as per GON rules is calculated to be Rs. 280,707,294.45. The per km cost including VAT is Rs. 22,679,768.54.

Table 21: Summary of Cost Estimate

Part	Description	NRs.
Part 1	General	6,661,758.73
Part 2	Site Clearance	1,353,841.48
Part 3	Earthwork	12,783,123.37
Part 4	Structures (Stability, Cross-Drainage and Side Drainage)	112,884,917.98
Part 5	Pavement Works	80,368,297.92
Part 6	Road Furniture and Traffic Safety Measures	6,541,298.80
Part 7	Bio-Engineering Works	908,403.75
Part 8	Day Works	1,281,925.00
A	**Civil Works (Part 1 to Part 8)**	**222,783,567.03**
B	VAT (13% of A)	28,961,863.71
C	**Total Cost including Base Cost and VAT (A+B)**	**251,745,430.74**
D	Cost per KM as per Total Cost including Base Cost and VAT (C / Length in km)	22,679,768.54
E	Work Charge Staff and Small Miscellaneous Expenses (3% of A)	6,683,507.01
F	Provision of Physical Contingency (10% of A)	22,278,356.70
G	**Total Cost including Base Cost, VAT, Work Charge Staff and Small Miscellaneous Expenses and Physical Contingency (C+E+F)**	**280,707,294.45**

7.2 Quantity Estimate

For estimating the cost of the project, detailed quantity estimation had been done for each item of works to be included in the project activities. The detail quantity estimates have been provided in Volume 2 Cost Estimate and the sheets of quantity estimation. The quantities of earthwork, embankment filling, backfilling, stone masonry walls, gabion walls, drain and pavement are calculated by design software. Cross drainage structures and others are calculated separately.

7.3 Analysis of Rates

For estimating the cost of each item of works, prevailing norms of DoLIDAR and DOR for rate analysis has been used throughout. Rate analysis of each of the items has been carried out according to the approved norms of DoLIDAR and approved district rates of Okhaldhunga and Udayapur of fiscal year 2073/2074.

CHAPTER - 8

ENVIRONMENT PROTECTION MEASURES

During field visit, few minor slides / erosions were observed. The location requires special consideration during construction period. Gabion walls and toe walls have been proposed in the design as noted essential during the site visit. Also, bioengineering works has been proposed in other locations where landslides have occurred though small in scale. In many locations, where erosion has been witnessed, gabion breast walls have been proposed.

Table 22: Location of Landslides and Bio-Engineering Works

S. No	Chainage		Length (m)	Slope Height (m)	Quantity (m2)
	From	To			
1	3+320	3+360	40.00	15.00	600.00
2	Miscellaneous		100.00	15.00	1500.00
		Total	**140.00**	**30.00**	**2100.00**

Suitable materials obtained from excavation will be used for embankment filling, and backfilling of structures. Despite this, the surplus excavated materials obtained will be disposed at construction site as required. Wherever possible, the surplus spoil will be used to fill eroded gullies, quarries and depressed areas. Dry stone toe walls are required in some locations for disposal of spoils.

The soil and rocks may derive from the road cut during the road construction period. The cut materials can be disposed on the flat land of the ridge and open and stable area along the road alignment.

As per findings of field visit, following environmental protection measures have been proposed in design and cost estimate:

Table 23: Environment Protection Measures

S.N.	Environmental Protection Measures
1	Provision of spoil mass transportation up to nearby tipping sites
2	Bioengineering works along with small slope protection civil structures
3	Inlet and outlet protection works of cross drainages / culverts to mitigate the damage to cultivated land, private property etc
4	Provision of breast walls in potential and existing landslide area
5	Proper drainage management to protect the road and roadside slope from adverse effect of accumulated water

CHAPTER - 9

CONCLUSION AND RECOMMENDATIONS

The road serves as the main access to different parts of the district. The people will be encouraged in getting the better benefit of the road which results in better living standard of the local people.

All the settlements along the proposed road alignment and its neighborhood have immense potential of vegetable, fruit and other cash crops production. People can increase the production of cereal crops and cash crops so that it can be exported. This will increase the cash flow in the area. Hence, the road is recommended for construction.

The detailed survey, design and study revealed many facts of the alignment and based on close observation and analysis, it is recommended that:

- Alignment passes through steep terrain thus retaining structures are necessary.
- Drain should be constructed along the alignment for sustainability (in term of damage) of road
- Pavement should be DBST

Annex 1: List of Bench Mark and Description Card

BM No	Northing (N)	Easting (E)	Elevation (Z)	Bench Mark Fixed on:
BM 01	3022780.774	451337.241	1650.000	Concrete Pillar
BM 02	3022873.941	451433.79	1649.721	Concrete Pillar
BM 03	3022899.602	451748.226	1632.677	Shiva Temple
BM 04	3023099.79	452314.049	1643.233	Concrete Slab of House
BM 05	3023710.736	453376.641	1615.567	Big Boulder
BM 06	3024097.531	453348.596	1500.767	Slab of Suspension Bridge
BM 07	3024136.405	453356.39	1500.749	Slab of Suspension Bridge
BM 08	3023406.921	454355.215	1512.849	Concrete Slab of House
BM 09	3023363.619	454454.244	1500.67	Concrete Slab of Resort
BM 10	3023267.364	455229.227	1643.043	Concrete Slab of House
BM 11	3023242.284	455234.254	1360.964	Concrete Slab of House
BM 12	3020691.905	455598.194	1194.33	Concrete Slab of House
BM 13	3020709.26	455655.398	1191.779	Slab of Gate

Annex 2: Vertical Curve Data

Vertical Curve Data									
VIP No.	VIP		Length	BVC		MVC		EVC	
	Ch.	Elevation		Ch.	Elevation	Ch.	Elevation	Ch.	Elevation
1	0+000.00	1644.427	0	0+000.00	1644.427	0+000.00	1644.427	0+000.00	1639.688
2	0+103.52	1639.769	30	0+088.52	1640.444	0+103.52	1639.917	0+118.52	1639.688
3	0+245.60	1639.001	40	0+225.60	1639.109	0+245.60	1638.891	0+265.60	1638.452
4	0+357.60	1635.929	30	0+342.60	1636.34	0+357.60	1636.098	0+372.60	1636.194
5	0+453.76	1637.627	20	0+443.76	1637.45	0+453.76	1637.681	0+463.76	1638.019
6	0+590.98	1643.008	40	0+570.98	1642.224	0+590.98	1642.596	0+610.98	1642.144
7	0+715.56	1637.627	20	0+705.56	1638.059	0+715.56	1637.675	0+725.56	1637.386
8	0+825.01	1634.987	30	0+810.01	1635.349	0+825.01	1635.177	0+840.01	1635.387
9	0+987.66	1639.322	30	0+972.66	1638.922	0+987.66	1639.136	1+002.66	1638.979
10	1+066.46	1637.518	30	1+051.46	1637.861	1+066.46	1637.717	1+081.46	1637.971
11	1+165.48	1640.508	20	1+155.48	1640.206	1+165.48	1640.451	1+175.48	1640.582
12	1+267.21	1641.257	25	1+254.71	1641.165	1+267.21	1641.412	1+279.71	1641.968
13	1+323.31	1644.448	60	1+293.31	1642.742	1+323.31	1643.349	1+353.31	1641.758
14	1+482.81	1630.148	76	1+444.81	1633.555	1+482.81	1631.948	1+520.81	1633.943
15	1+691.87	1651.026	30	1+676.87	1649.528	1+691.87	1650.741	1+706.87	1651.386
16	1+761.98	1652.708	30	1+746.98	1652.348	1+761.98	1652.985	1+776.98	1654.176
17	1+862.67	1662.562	60	1+832.67	1659.626	1+862.67	1661.439	1+892.67	1661.006
18	1+937.15	1658.698	50	1+912.15	1659.995	1+937.15	1659.392	1+962.15	1660.178
19	2+054.47	1665.642	40	2+034.47	1664.458	2+054.47	1665.245	2+074.47	1665.236
20	2+134.98	1664.008	40	2+114.98	1664.414	2+134.98	1664.387	2+154.98	1665.118
21	2+298.98	1673.108	50	2+273.98	1671.721	2+298.98	1672.463	2+323.98	1671.916
22	2+404.06	1668.098	30	2+389.06	1668.813	2+404.06	1667.83	2+419.06	1666.312
23	2+685.11	1634.625	30	2+670.11	1636.411	2+685.11	1634.858	2+700.11	1633.769
24	2+745.33	1631.187	30	2+730.33	1632.043	2+745.33	1631.032	2+760.33	1629.713
25	2+897.94	1616.186	30	2+882.94	1617.66	2+897.94	1616.326	2+912.94	1615.272
26	3+051.60	1606.826	20	3+041.60	1607.435	3+051.60	1606.887	3+061.60	1606.459
27	3+180.02	1602.113	30	3+165.02	1602.663	3+180.02	1601.877	3+195.02	1600.62
28	3+328.26	1587.357	100	3+278.26	1592.334	3+328.26	1587.734	3+378.26	1583.887

29	3+402.72	1582.189	30	3+387.72	1583.23	3+402.72	1582.012	3+417.72	1580.442
30	3+595.36	1559.747	30	3+580.36	1561.494	3+595.36	1559.962	3+610.36	1558.859
31	3+694.34	1553.889	30	3+679.34	1554.777	3+694.34	1553.669	3+709.34	1552.12
32	3+917.72	1527.541	30	3+902.72	1529.31	3+917.72	1527.809	3+932.72	1526.844
33	3+982.12	1524.549	24	3+970.12	1525.106	3+982.12	1524.396	3+994.12	1523.379
34	4+203.46	1502.973	50	4+178.46	1505.41	4+203.46	1503.694	4+228.46	1503.419
35	4+312.73	1504.922	30	4+297.73	1504.654	4+312.73	1504.664	4+327.73	1504.159
36	4+400.89	1500.438	20	4+390.89	1500.947	4+400.89	1500.513	4+410.89	1500.228
37	4+560.11	1497.094	20	4+550.11	1497.304	4+560.11	1497.169	4+570.11	1497.184
38	4+678.29	1498.158	20	4+668.29	1498.068	4+678.29	1498.072	4+688.29	1497.905
39	4+783.55	1495.498	20	4+773.55	1495.751	4+783.55	1495.583	4+793.55	1495.584
40	4+881.21	1496.334	20	4+871.21	1496.248	4+881.21	1496.263	4+891.21	1496.137
41	5+016.49	1493.674	0	5+016.49	1493.674	5+016.49	1493.674	5+016.49	1491.248
42	5+585.35	1490.33	30	5+570.35	1490.418	5+585.35	1490.581	5+600.35	1491.248
43	5+746.85	1500.21	20	5+736.85	1499.598	5+746.85	1500.306	5+756.85	1501.205
44	5+974.47	1522.858	80	5+934.47	1518.878	5+974.47	1520.87	6+014.47	1518.885
45	6+183.47	1502.1	30	6+168.47	1503.59	6+183.47	1502.286	6+198.47	1501.353
46	6+236.67	1499.45	30	6+221.67	1500.197	6+236.67	1499.263	6+251.67	1497.953
47	6+408.81	1482.274	40	6+388.81	1484.269	6+408.81	1482.724	6+428.81	1482.077
48	6+455.17	1481.818	40	6+435.17	1482.015	6+455.17	1481.372	6+475.17	1479.836
49	6+541.81	1473.23	30	6+526.81	1474.717	6+541.81	1473.455	6+556.81	1472.644
50	6+656.77	1468.741	30	6+641.77	1469.327	6+656.77	1468.515	6+671.77	1467.25
51	6+855.01	1449.035	30	6+840.01	1450.526	6+855.01	1449.221	6+870.01	1448.289
52	6+957.08	1443.961	30	6+942.08	1444.707	6+957.08	1443.778	6+972.08	1442.483
53	7+314.03	1408.797	30	7+299.03	1410.275	7+314.03	1408.998	7+329.03	1408.124
54	7+555.93	1397.941	20	7+545.93	1398.39	7+555.93	1397.885	7+565.93	1397.27
55	7+640.30	1392.277	40	7+620.30	1393.62	7+640.30	1392.669	7+660.30	1392.503
56	7+702.84	1392.985	30	7+687.84	1392.815	7+702.84	1392.756	7+717.84	1392.239
57	7+823.79	1386.967	20	7+813.79	1387.465	7+823.79	1386.868	7+833.79	1386.075
58	8+168.94	1356.169	50	8+143.94	1358.4	8+168.94	1356.611	8+193.94	1355.705
59	8+251.54	1354.635	30	8+236.54	1354.914	8+251.54	1354.557	8+266.54	1354.045
60	8+356.56	1350.505	30	8+341.56	1351.095	8+356.56	1350.316	8+371.56	1349.16
61	8+573.68	1331.035	20	8+563.68	1331.932	8+573.68	1331.135	8+583.68	1330.538
62	8+682.83	1325.607	20	8+672.83	1326.104	8+682.83	1325.556	8+692.83	1324.908
63	8+947.74	1307.081	20	8+937.74	1307.78	8+947.74	1307.132	8+957.74	1306.586
64	9+188.46	1295.163	30	9+173.46	1295.906	9+188.46	1294.976	9+203.46	1293.672
65	9+285.81	1285.487	40	9+265.81	1287.475	9+285.81	1285.952	9+305.81	1285.358
66	9+358.97	1285.015	30	9+343.97	1285.112	9+358.97	1284.78	9+373.97	1283.978
67	9+471.66	1277.227	30	9+456.66	1278.264	9+471.66	1277.464	9+486.66	1277.137
68	9+569.60	1276.637	30	9+554.60	1276.727	9+569.60	1276.474	9+584.60	1275.893
69	9+673.91	1271.462	30	9+658.91	1272.206	9+673.91	1271.313	9+688.91	1270.123
70	9+980.83	1244.069	30	9+965.83	1245.408	9+980.83	1244.309	9+995.83	1243.691
71	10+130.69	1240.293	20	10+120.69	1240.545	10+130.69	1240.187	10+140.69	1239.617
72	10+320.63	1227.454	20	10+310.63	1228.13	10+320.63	1227.567	10+330.63	1227.231
73	10+429.83	1225.019	20	10+419.83	1225.242	10+429.83	1224.941	10+439.83	1224.484
74	10+775.49	1206.538	0	10+775.49	1206.538	10+775.49	1206.538	10+775.49	1199.844
75	10+876.98	1199.931	30	10+861.98	1200.907	10+876.98	1200.153	10+891.98	1199.844
76	10+984.62	1199.307	30	10+969.62	1199.394	10+984.62	1199.126	10+999.62	1198.496